Water Resource Policy Development in the United State of America with Emphasis on New Flood Control Policies and the Decision Making Process as Pertains to the Mississippi River Valley

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INTRODUCTION

Flood Control policies have evolved with time, engineering knowledge, environmental awareness and needs of the citizens of the United States. The developments of these policies as they pertain to the Mississippi River Valley is presented in this paper. History of these events will be used to show the development of engineering, and environmental policies as well as economic policies.

HISTORY

General

The Mississippi River rises in the lake and forest country of north-central Minnesota and flows 2,350 miles to its mouth in the Gulf of Mexico. Over this journey, it falls 1,463 feet and drains 1.25 million square miles or 41 percent of the land area of the continental United States.

That portion of the Mississippi River drainage lying above its confluence with the Ohio River at Cairo, Illinois, is commonly referred to as the upper Mississippi River Basin. (Note that for the Mississippi River itself, the reach upstream from St. Louis is called the upper Mississippi River, the reach between St. Louis and Cairo is the middle Mississippi River, and the reach downstream from Cairo is called the lower Mississippi River.) The upper Mississippi River Basin encompasses approximately 714,000 square miles, which is 57 percent of the total Mississippi River Basin and 23 percent of the land area in the continental United States. This area includes its principal tributary, the Missouri River Basin, which drains 529,000 square miles above its mouth at St. Louis, Missouri, including 9,700 square miles in Canada. The Missouri River drains 74 percent of the upper Mississippi River Basin but contributes only 42 percent of the long-term average annual flow at St. Louis.

As the Mississippi River leaves the northern woodlands and lakes above Minneapolis-St. Paul, Minnesota, it meanders southward past fertile prairies, villages, and cities. Along the way, numerous tributaries join the Mississippi River and add to its flow. The drainage area of the Mississippi River has six major subbasins: the upper Mississippi, Missouri, Ohio, Arkansas, White, and lower Mississippi. Historically, the Missouri and Arkansas Rivers have contributed greater amounts of sediment, while the Ohio River contributes the greater percentage of water discharge and the least concentration of sediment. The floodplain along the main stem of the Mississippi River varies in width from approximately three-quarters of a mile to more than 14 miles, and averages about 5 miles wide.

The Missouri River rises along the Continental Divide in the northern Rocky Mountains and flows

generally easterly and southeasterly to join the Mississippi River near St. Louis, Missouri. Its drainage area includes all of Nebraska and parts of Missouri, North Dakota, Kansas, Colorado, Wyoming, Montana, South Dakota, Iowa, Minnesota, and Canada. Hydrologically, the Missouri River Basin is divided into two portions, with demarcation at Sioux City, Iowa. (Floodplain Management Assessment of the Upper Mississippi River and Lower Missouri River and Tributaries, U.S. Army Corps of Engineers, 1995.)

HISTORICAL EVALUATION

The Upper and Middle Mississippi River History (1866-1993)

Verbatim from Flood Plains Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries, U.S. Army Corps of Engineers, 1995.

✌On the Mississippi River main stem, the flood of 1993 played itself out on a landscape largely established by 1940. That landscape--physical, ecological and hydraulic--wasdramatically different from the one sculpted in the eons before Europeans and Americans arrived in the Mississippi River valley. The dominant player in defining the landscape was the Federal Government acting for navigation interests, floodplain farmers and conservationists.

By 1940, members of these groups had come to expect Federal aid in their efforts to use the river and its valley. With the flood control acts authorized for the upper Mississippi River between 1917 and 1938, Congress approved the first major Federal efforts to fortify the upper and middle Mississippi River=s agricultural levees. After 1938, Congress and the Corps--at the insistence of floodplain occupants--expanded flood control to include urban areas, reservoir projects, and the river=s tributaries. The greatest changes in the upper Mississippi River Basin after 1940 would occur in the river=s tributaries and uplands. Floodplain management received little attention before 1960. After 1960 it would get greater notice, but old patterns would dominate floodplain and flood control policy up to the 1993 flood.

More than any other agency, the U.S. Army Corps of Engineers has reshaped the upper and middle Mississippi River. To understand how and why the Corps first became involved with the river and how the Corps initially transformed the river=s landscape, we have to examine navigation improvements. Navigation improvements have been among the most powerful influences defining the Mississippi River and its flood plains between the Ohio River and Minneapolis.

Before 1866, the river-especially above St. Louis-still possessed most of its natural character. Trees filled and enshrouded it. Hundreds of islands, some forming and others being cut away, divided it, dispersing its waters into innumerable side channels and backwaters. During high water, the river spread into its vast flood plains, filling lakes and sloughs, covering low-lying prairies, and flowing through the bottom land forests. Sandbars, hundreds in the main channel alone, segmented the natural river into a series of deep pools separated by shallows. Before the Civil War, the Corps had removed some rock from the Des Moines and Rock Island Rapids, had improved the St. Louis and Dubuque harbors, and--particularly below St. Louis--had pulled some trees from the river and had cut others from the river=s banks. But, this work had been local and limited.

Midwesterners and the ever increasing stream of immigrants inhabiting the Mississippi River Valley demanded more extensive and systematic improvements. To them, the river was a poorly constructed highway that promised to become the region=s greatest commercial artery, if properly improved. With increasing intensity from 1866 on, they sought access to the Atlantic Ocean and the world through the Mississippi River to realize their manifest destiny. That destiny, they believed, was to become a commercial and industrial power as strong as the East, as well as the Nation=s breadbasket. To fulfill this destiny, they would lobby Congress to reshape the upper Mississippi River. In response,

Congress has authorized four broad navigation projects for the upper Mississippi River between Minneapolis and St. Louis since 1866; the 4-, 4 , 6- or 9-foot depth if it fell as low as it did in 1863. For the Mississippi River between the Illinois River and St. Louis, Congress authorized a 6-foot channel in 1881 and that same year approved an 8-foot channel for the river between St. Louis and the Ohio River.

In 1866, States along the upper and middle river convinced Congress to authorize the Corps to establish a 4-foot channel through dredging, snagging, clearing overhanging trees, and recovering sunken vessels. To work on this project and on surveys of the upper river and its tributaries, the Corps established offices in St. Paul, Minnesota, and Keokuk, Iowa, in 1866. And in 1873, the Corps transferred duties for the middle Mississippi River from its Office of Western Improvements in Cincinnati to St. Louis. With the 4-foot project, and its new District Offices, the Corps became the first agency to acquire a full-time management role on the upper and middle Mississippi River.

Under the early improvement efforts on the middle Mississippi River and the 4-foot channel project on the upper river, the Corps began changing the river's landscape, hydraulic regime, and ecosystems. By removing snags, leaning trees, and sandbars, the Corps began--if only slightly--allowing the river to move faster down the main channel. The Corps simply did not have the equipment, personnel, or authority to make significant and lasting changes.

As the Midwest's population and agricultural production grew following the Civil War and as railroads began monopolizing bulk commodity transportation in the Midwest, pressure mounted on Congress to authorize more significant improvements. Responding to popular demand and strong lobbying by the timber industry, farmers, and upper river States, Congress authorized the 4 foot channel project for the upper river in 1878. Three years later, Congress approved a 6-foot channel for the Mississippi River between the Illinois River and St. Louis and an 8-foot channel for the river between St. Louis and the Ohio River. Under these projects, Congress directed the Corps to make the upper and middle Mississippi River into a predictable and reliable highway. This meant that the Engineers would have to create a permanent, continuous channel for the entire river between St. Paul and the Ohio River.

To achieve the 4 -,6- and 8-foot channel depths, the Corps constricted or narrowed the main channel and cut off many of its side channels. They accomplished this by building wing dams, closing dams, and riprapping the river's banks. Long, narrow piers of rock and brush, wing dams jutted into the river from the main shoreline or from an island. Placed in a series along one or both sides of the channel, the wing dams reduced its width at low flows. Funneled between the dams, the faster moving river carried more sediment. Some of this sediment the river deposited in the calmer waters behind or between the wing dams. Within a few years, the space between the dams began filling with sand and plants. On the middle river, the Engineers used hurdles. The structures were similar to wing dams but were made by driving piles into the riverbed and weaving willow mats between them. So much silt entered the Mississippi River from the Missouri River that the willow mats filled quickly with sediment.

Channel constriction demanded a strong flow of water in the main channel. During the late summer or early fall, the Mississippi River usually became a shallow, slow-moving stream. Droughts had the same effect but could last an entire season. To deliver more water to the main channel, the Engineers built closing dams. These dams ran from the shore to an island or from one island to another or across side channel openings. While the river could flow over the closing dams when high, for much of the year the dams directed water into the main channel. Despite navigation improvements made under the 4 -foot channel project, steam boat traffic on the Upper Mississippi River declined; railroads still offered greater reliability and better economies of scale.

In 1902, railroad baron James J. Hill declared that shipping on the upper Mississippi River had declined so much that the river was no longer worth improving. Hill scared cities and business interests along the river and triggered the first sustained river improvement movement by Midwesterners. With a strong national interest in waterway development, a positive survey report by the Corps, and a railroad car shortage in 1906 that left grain rotting at Midwestern terminals, navigation interests pushed for and

won the 6-foot channel project for the upper Mississippi River on March 2, 1907. Under this project, the Corps intensified channel constriction, further narrowing the upper river. In 1927, Congress would increase the middle Mississippi River operating depth from 8 to 9 feet. Channel constriction aided by dredging would be the primary methods here as well.

By 1930 the Federal Government, pushed by navigation interests, had become the most influential agency on the middle and upper Mississippi River. Through the channel constriction projects, the Corps had transformed the Mississippi River between St. Paul and the Ohio River. In the 140-mile reach between the Twin Cities and La Crosse, they had built over 1,000 wing dams, and over 300 between St. Louis and the Ohio River. But navigation supporters were not alone in transforming the Mississippi River to meet their dreams. Over the same era, floodplain farmers would greatly alter the river between Rock Island and Cape Girardeau.

Outside the navigation interests and the Corps, floodplain farmers became the primary interest actively transforming the Mississippi River and soundly establishing their stake in how it would be managed. The origin of the Mississippi River=s levee system is largely a history of private development. Some farmers began building levees on the upper and middle river before the Civil War. Soon after the war, they organized into levee districts and began the first concerted effort to secure the river=s flood plains for agriculture. They extended and raised levees and began draining the lands behind them. Before the Corps became involved in levee construction, these farmers had defined many of the flood plains that would be taken from the river. Whereas channel constriction had altered the whole upper river, reclamation and levee building would transform the river most significantly below Rock Island.

The Corps of Engineers reluctantly entered flood control on the upper Mississippi River under its navigation improvement authority. During the 1880s, individuals and organizations occupying the floodplain began pushing for Federal help. As early as 1884, the Sny Island Drainage District--enclosing over 110,000 acres-- south of Quincy, Illinois, asked the Federal Government to rebuild its 50-mile-long levee. The Corps reviewed the project and concluded that the levee did not help navigation and successfully recommended against Government support. But the levee district persisted, and in 1886, 1888, 1890, 1892 and 1896 Rivers and Harbors Acts, Congress authorized funding to preserve portions of the Sny Island levee in danger of eroding. The Engineers used this money to repair and riprap the levee and to build wing dams to throw the river=s current away from it.

Pressure also continued from other levee proponents, and in 1894, Congress instructed the Corps to survey the Mississippi River=s west bank from Flint Creek, just north of Burlington, Iowa, to the Iowa River, and the river=s east bank from Warsaw to Quincy, Illinois. Congress directed the Corps to determine how levees could help navigation Based on the corps surveys, Congress, in 1895, authorized funding for both levees.. In each case, the Corps was to improve navigation Aby preventing the water from overflowing the natural and artificial banks along that part of the river, and deepening the channel,.. The Corps completed the nearly 5-mile Warsaw to Quincy Levee in 1896 and the 35-mile Flint Creek Levee in 1900.

By 1900, Congress had directed the Corps to build or protect some of the most important agricultural levees on the upper Mississippi River. In doing so, Congress avoided difficult constitutional questions about the Federal Government=s role in flood protection. From its origins, the American Government had been reluctant to fund infrastructure projects because they so often benefited local or regional interests. But, from the Corps= perspective, working on levees established contradictory approaches to managing the upper river. Corps engineers criticized protecting or building levees in the name of navigation because levees designed for high water flows scoured and placed sediment differently than channel constriction works designed for low flows. Considering Corps protests and questions about the Federal Government=s role in flood control, Congress authorized no more levee work for the upper river until the 1917 Flood Control Act.

This did not stop farmers along the river from building levees and claiming more of the river=s

floodplain. In 1914, the Mississippi River Commission reported that 52 levee and drainage districts had been created between Cape Girardeau, Missouri, and Rock Island. While most of the levees were low and poorly built, they defined the first major taking of the river's flood plains. The Mississippi River Commission's report came at the end of one of the strongest periods of levee district formation on the middle and upper river. Seventeen, over half, of Illinois' Mississippi River levee districts were formed between 1905 and 1916. Through their efforts, farmers below Rock Island established their stake in how the upper Mississippi River would be managed for flood control and floodplain development.

Congress had created the Mississippi River Commission in 1879 to develop plans for improving navigation, to "prevent flooding," and to generally promote commerce. Its flood prevention authority extended only to planning efforts, however. Not until the flood of 1882 did the Commission receive authority to build levees. But this authority was only for improving navigation and it applied to the river below Cairo. In the 1913 River and Harbor Act, Congress extended the Commission's authority to Rock Island.

In a 1912 article on reclamation, Charles W. Durham, who had been the local engineer in charge of the Flint Creek Levee for the Corps, captured the significance of the reclamation to many Midwesterners. He asserted that:

> Aside from the pecuniary considerations, it is manifest that the conversion of a low, swampy and almost worthless tract into an aggregation of fertile farms with appropriate dwellings and farm buildings occupied by an industrious and prosperous population well provided with schools and good roads and reasonably insured against the inroad of malarious diseases, will be of great and lasting benefit to the public welfare and public health, which are important requirements of the drainage laws of the upper Mississippi valley states.

Durham further contended that it had "become imperative to protect low lands from overflow by means of levees and to get rid of surface water, seepage, swamps, etc., by means of ditches and pumps,..." because good land was becoming scarce and productive lands in the floodplain had to be preserved. "Thus the matter of conservation and improvement of the soil," he declared, "has become one of the most potent questions of the day and applies with force to the valleys of the Mississippi and its tributaries." Durham represented the mind-set of most Americans during this era--the same mind-set underlying the push for the river's development as a navigation corridor. Under his mind-set, failing to use the Nation's bountiful natural resources was wasteful.

Responding in part to States along the Mississippi River, Congress passed an official flood control act in 1917. The country's first flood control act, it allowed the Corps to work on levees from the Head of Passes in Louisiana to Rock Island and on the Sacramento River, in California. This act, more so than the 1936 Flood Control Act, marks the formal beginning of the Corps involvement in flood control on the upper and middle Mississippi River. Through this act, the Federal Government assumed an official role in securing the Mississippi River's flood plains for agriculture and gave the Corps a new mission for managing the middle and upper Mississippi River, a mission Congress strengthened in the 1928 Flood Control Act. Under these two acts, the Corps helped fortify levees in 11 levee and drainage districts that enclosed over 260,000 acres of floodplain.

Then, in 1936, congress passed the first national flood control act. Along with the 1938 Flood Control Act, this act broadened the Corps' role in flood control on the Mississippi River. These acts provided for flood control reservoirs, urban or local flood protection projects, and floodplain management. For the middle and upper river's main stem, however, the acts focused on agricultural levees. Under the 1936 flood Control Act, congress authorized 26 projects for the Mississippi River's main stem above the Ohio River. Of these, 25 called for raising and enlarging existing levees protecting agricultural lands. Only the East St. Louis and Vicinity project was authorized to protect an urban area. Congress extended its protection of the main stem's agricultural levees in the 1938 Flood Control Act. The five levee improvement projects authorized in this act were to protect existing levee and drainage district in Illinois between Alton and the mouth of the Ohio River. Together with the agricultural levee

improvements authorized under the 1936 act, these projects fortified most of the levee system on the Mississippi River in Missouri and Illinois. And as the Corps had reinforced the levee system above Alton under the acts preceding 1936, the Corps had helped secure most of the important agricultural levees between Rock Island and the Ohio River.

Congress extended the Corps' flood control work to the middle and upper river's tributaries in the 1936 act. Congress had authorized improvement of many of the Illinois River's agricultural levees in the 1928 act, but little work had been approved for other tributaries. In 1936, Congress authorized 15 projects for the Illinois River, 14 for agricultural levee and drainage districts and one for a levee setback and floodway improvement. Demonstrating its willingness to consider non-levee projects, Congress authorized four flood control reservoirs for the main stem's tributaries in the 1936 act and another in the 1938 act. In 1936, it provided for dams and reservoirs at Decorah, Iowa, on the Upper Iowa River, and for the Des Moines River about 60 miles below Des Moines (Red Rock project). For Illinois, Congress approved the Carlyle dam and reservoir on the Kaskaskia river, and for Minnesota, it approved the Lac qui Parle dam and reservoir on the upper Minnesota River. The Decorah, Carlyle, and Red Rock -projects were specifically aimed at protecting urban populations, although they guarded agricultural lands as well. The Lac qui Parle project had the more general objective of safeguarding the Minnesota River valley downstream. In 1938, Congress authorized the Coralville dam and reservoir, on the Iowa River, to protect Iowa City and some 1,073 square miles downstream. With these projects, Congress had authorized four of the major reservoirs that would be built on the upper Mississippi River's tributaries above the Missouri River's mouth (Decorah would become a diversion project).

In the acts passed between 1886 and 1938, congress established the Federal Government's role in protecting property and people in the upper and middle Mississippi River valley from flood. It instilled the expectation that the Federal Government would do so. Through these acts, Congress endorsed and encouraged floodplain development for agriculture. And the acts solidly anchored the Corps' and congress' reliance on levees and other structural measures. When added to the navigation improvement mission, the flood control responsibility extended and deepened the Corps' management role on the Mississippi River.

Combined with channel constriction, reclamation had transformed the landscape, environment and hydraulic character of the Mississippi River between Rock Island and the Ohio River. Whereas moderate floods above Rock Island could still spread over most of the natural floodplain, only larger floods could do so below rock Island. Here the river was now constricted at both high and low water.

By the 1920s some conservationists argued that reclamation, channel constriction, pollution, siltation, and overuse threatened to overwhelm the river's fish and wildlife. Consequently, they initiated two efforts to reserve and develop large parts of the upper Mississippi River for native plants and animals and for recreation. First, they tried to establish a national park, and second, they sought to create a national wildlife and fish refuge. Through these two movements, conservationists more clearly defined their visions for the river and organized to achieve those visions. Proposed in the early 1900s, the park movement gained strength after 1916. By 1921, however, it had stalled and conservationists started a new movement.

In 1922, Will Dilg--the Izaak Walton League's co-founder--suggested that Congress create a 260-mile long national fish and wildlife refuge between Wabasha, Minnesota, and Rock Island. To convince Congress to act quickly and positively, refuge proponents argued that the upper Mississippi River valley faced an environmental crisis. If Congress did not create the refuge immediately, the Nation would lose one of its greatest fish and wildlife reserves, important commercial food and fur resources, the best recreation area in the central United States, and spectacular scenery. To bolster their arguments, they secured experts and concerned citizen groups from around the country to testify for the bill. H.C. Oberholser, speaking for the Biological Survey, asserted that "we must, if we are to keep up the supply of our wild life, do something before it is too late; and it is rapidly becoming too late."

Under Dilg's leadership, conservationists used the draining of floodplain wetlands to push for the

refuge. In 1923, landowners in an area called Winneshiek Bottoms proposed to drain much of this 30-mile-long wetland for agricultural use. The bottoms comprised an area of about 13,000 acres below Lansing, Iowa, on the Wisconsin shore and about 15,000 acres above Lansing on the Iowa side. This project showed that farmers above Rock Island were beginning to think about using the river's floodplain wetlands.

Responding to pleas by conservationists and to national support for the refuge, Congress passed the refuge bill, and President Calvin Coolidge signed it on June 7,1924, creating the Upper Mississippi River Wildlife and Fish Refuge. Congress appropriated $1.5 million for purchasing land between Rock Island and Wabasha, and by 1929, the Federal Government had bought over 100,000 acres for the refuge, which would eventually include 195,000 acres. The refuge further defined the upper Mississippi River's landscape by removing much of this land from potential reclamation.

Just as conservationists won the refuge, navigation on the upper river died. By 1918, virtually no through traffic moved between St. Paul and St. Louis. As the region's need for a diverse transportation system had grown, its shipping options had declined, creating a transportation crisis. Railroad car shortages, the Panama Canal's opening in 1914, several Interstate Commerce Commission decisions, and the failure of channel constriction to restore river traffic erected, some Midwesterners declared, an "economic barrier" around their region. Although the Engineers had built thousands of wing dams and had closed many of the river's side channels, they had been unable to create a dependable navigation channel. All to frequently, droughts and floods made the channel impassable. Rail car shortages, occurring in 1906-1907, during World War I, and in 1921, caused acute, short-term shipping crises, and pointed out the Midwest's dependence on railroads. The Panama Canal's opening in 1914 redefined the Midwest's transportation problems. While railroad car shortages had been infrequent, the Panama Canal created a problem that promised to become steadily worse. Economically, the Panama Canal moved the East and West coasts closer to each other while moving the Midwest farther away from both coasts. Businesses could ship goods from New York to San Francisco through the Panama Canal cheaper than Midwesterners could ship goods to either coast by rail.

In response, Midwestern business and navigation interests initiated another movement to revive navigation, a movement that surpassed all previous movements. Between 1925 and 1930, they fought to restore commerce and to persuade congress to authorize a new project for the river, one that would allow the river to truly compete with railroads. It would draw support from the largest and smallest businesses in the valley, from most of its cities, from the Midwest's principal farm organizations, and from the major political parties. Responding to this movement, Congress included the 9-foot channel project in the 1930 Rivers and Harbors Act.

With the 9-foot channel project, Congress authorized a new approach to navigation improvement on the upper Mississippi River. Rather than narrowing the river and depending solely on the flow of water from the basin, Congress approved 23 locks and dams to store water in reservoirs or pools. Only in this way, the Engineers insisted, could they guarantee a 9-foot channel.

Placing locks and dams in the river was not a new idea. During the second decade of the 20th century, navigation and hydroelectric power backers joined to build two structures. In 1913, the Keokuk and Hamilton Power Company completed a hydroelectric power plant and a lock and dam at Keokuk, Iowa. While the reservoir created by the new dam flooded the Corps canal bypassing the Des Moines Raids, it provided a deep channel for 41 miles upstream from the dam. The project also helped floodplain farmers. The hydroelectricity produced by the new plant allowed drainage districts to employ electric pumps to more quickly and thoroughly drain their lands. And the Keokuk and Hamilton Power Company paid for the entire lock and dam project.

Hydroelectric power supporters did not initiate the building of a lock and dam in the Twin Cities but they did define how the Corps built the project. In 1894, after decades of lobbying, navigation advocates in Minneapolis finally convinced Congress to build two low locks and dams to make their city the head of navigation on the Mississippi River. While the project was underway, hydroelectric power

came of age and its proponents in the Twin Cities began lobbying for a new project that called for one high dam. In the 1910 River and Harbor Act, Congress granted their wish. After revamping the project by removing the original Lock and Dam 2, which had been completed in 1907, and rebuilding Lock 1 to the new height, the Corps completed the project in 1917. It included the base for a hydroelectric power plant, on which the Ford Motor Company would open its station in 1924.

By 1925, the Corps had learned that it could not achieve a 6-foot channel between Hastings, Minnesota, and St. Paul without a lock and dam. Pushed by navigation interests, ✌who advanced money for the preliminary surveys, borings and initial design work, ☮ Congress authorized Lock and Dam 2 for Hastings in the 1927 Rivers and Harbors Act and the St. Paul District completed the project in 1930. So by the eve of the 9-foot channel project, three dams were in place on the upper Mississippi River. Through the Keokuk and Lock and Dam 1 projects, hydroelectric power interests had gained a stake in how the river would be managed. Through all three projects, the precedent for navigation dams had been established.

To create a 9-foot channel, the corps chose locks and dams and quickly determined that the dams would have to be quite low. Numerous villages and cities rested just above ordinary high water. Railroads following the river on each bank were often just out of reach of high water. At larger river cities, industrial developments lined the stream closely. Because of the small difference between the natural high water mark and the elevation of railroads, buildings,and other structures along the river and because of the small range of the annual flood stages, the Engineers concluded that the dams would have to be designed not to increase flood stages. While they expected that contracting the river near the dams would increase the flood height at the dams by 1 foot, they had calculated that this effect would dissipate within a few miles above the dam. Given the location of dams, the Engineers expected no adverse effects from flooding by this effect.

Another constraint determined the height of the dams. For a large part of the river below Rock Island, the report noted, one or the other of the banks, and in some cases both banks were lined by levees. These levees made any considerable raising of the permanent low-water elevation a problem. Raising the river too much would leave parts of some levees wet all year that had previously been wet only at high and medium river stages. Being wet all the time would greatly weaken the levees. High dams, the Engineers therefore determined, were not possible. Heeding pressure from the conservationists, the Engineers also noted that low dams would not seriously flood the Upper Mississippi River Wildlife and Fish Refuge.

In 1940, the Corps completed the 9-foot channel project. Twenty-six locks and dams now crossed the river between Minneapolis and Alton. (Lower and Upper St. Anthony Falls Lock and Dams would be completed in 1956 and 1963, respectively. Lock and Dam 27 would be finished in 1964, bringing the total to 29.) The 9-foot channel project again reconfigured the upper Mississippi River■s landscape, hydraulic character, and environment. The pools created by the dams permanently flooded thousands of acres that had been seasonally flooded before. Because the Engineers took damage to cities, towns, and villages into consideration in planning the location of the dams, few of them would require special protection.. The greatest flowage effects would occur to agricultural lands, floodplain forests, and brush lands.

The middle Mississippi River also experienced a surge of work after 1930. Frederick J. Dobney, author of the St. Louis District history, reports that between 1930 and 1945, the District spent more on navigation improvements for the middle river than they had up to 1930. During this era, they built 768 dikes or hurdles, totaling 404,000 linear feet, and 224 revetments or bank protection projects, totaling 276,000 linear feet.

The upper and middle Mississippi River■s landscape as it existed on the eve of the 1993 flood had, for the most part, been shaped by 1940. Urban projects had yet to be built, but these would represent minor changes in the river■s flood plains compared to what had been done. Above Rock Island, where farmers had constructed few levees, the 9-foot channel reservoirs returned to the braided

channels and over-flowed flood plains. Between Rock Island and Alton, Illinois, the agricultural levees prevented the reservoirs from spreading out as much. Below Lock and Dam 26, Congress had provided for a 9-foot channel through dredging and continued channel constriction.

In 1940, navigation was still the primary use and the Corps the dominant agency. But other interests had staked their claims. Farmers had convinced the Federal Government to reinforce their investment in the river's flood plains. Hydroelectric power interests had acquired important points on the river, inundating the valley behind their dams to a level anticipating the 9-foot channel locks and dams. Conservationists had won the Upper Mississippi River National Wildlife and Fish Refuge, and compromises made under the 9-foot channel project signaled a new framework for managing the upper Mississippi River.

What role the government should play in protecting floodplain occupants had also been established. People expected the Federal Government to defend them and their property, largely at Federal expense. For the upper Mississippi River valley, this pertained mostly to the agricultural population. But some people began questioning this paradigm. In 1936, Harlan Barrows and his student, Gilbert White, both suggested alternative to the structural approach. In May 1936, on the eve of the government's entry into the national flood protection arena, Gilbert White, who would become one of the leading national experts on floodplain management suggested that land use planning might be an effective alterative to reducing flood damage. He argued the relocating structures and modifying farming practices in some flood plains might save more money than structural l flood control measures could, a position he articulated in his 1942 doctoral dissertation entitled Human Adjustment to Floods. Then, in a report to President Franklin Roosevelt in late 1936, the Water Resources Committee of the National Resources Board, which Barrows chaired, suggested that preventing floodplain growth should be tried where it would be cheaper than building a flood storage dam. "For the first time," Corps senior historian Martin Reuss observes, "an official government document recommended something other than building dams, flood walls, and levees to protect life and property." But Congress and the corps disagreed. Few Americans were ready to consider floodplain regulation--restricting floodplain use--until they perceived that structural solutions had failed or until enough Americans began viewing flood plains as more the untapped agricultural lands.

Finally, the power structure, the role of various stakeholders, had been well grounded. The Federal Government's hand was dominant throughout. At the request of navigation interests and floodplain farmers and through the Corps of Engineers, the Government had transformed the river for navigation and floodplain development. For conservationists and through the precursors of the Fish and Wildlife Service, it had carved out a large part for the upper Mississippi River valley for a fish and wildlife refuge, which it managed. As of 1940, navigation interests, farmers, and others who sought to develop the river's flood plains clearly dominated and would for many more years.

World War II interrupted flood protection work on the middle and upper Mississippi River. But even before the war's end, Congress and the Corps had returned to building the Nation's Flood protection infrastructure, and they continued their focus on structural projects. While the Corps was building the agricultural levees authorized in the 1936 and 1938 Flood Control Acts, Congress shifted its attention to urban projects on the Mississippi River and its tributaries. Following the 1938 act and up to the 1954 act, Congress authorized work for only two main stem agricultural levee districts--Prairie du Rocher and Sny Island--both in the 1946 Flood Control Act. In 1946, Congress also approved the Illinois River Flood Control Project, an unusual project in that it called for reclaiming a levee district from agriculture.

Urban levees were the principal focus, however. In 1944, Congress enacted local projects for Sabula, Des Moines, and Elkport, Iowa, and Galena, Illinois. Only Sabula lay on the main stem. In the 1948 Flood Control Act, Congress authorized no projects for the Mississippi River below the Twin Cities. It did approve a channel diversion project to protect Aitkin, Minnesota, on the Mississippi River north of Minneapolis, a project to defend South Beloit on the Rock River in Illinois (now deauthorized),

and a project to protect agricultural bottom lands along the Henderson River. In Section 205 of the 1948 act, Congress gave the Secretary of the Army the power to approve flood protection works under $2 million (today this limit is $5 million). Although the Corps has built many projects under this authority, these projects have not been examined in this discussion. In the 1950 Flood Control Act, Congress again focused on urban flood protection, authorizing projects for Canton and Cape Girardeau, Missouri, on the Mississippi River, and another urban project for Beardstown, on a small tributary of the Illinois River. In neither act did congress authorize agricultural projects for the main stem and only the Henderson River agricultural project for the upper river's tributaries.

Congress returned to the Mississippi River's agricultural levees in the 1954 Flood Control Act. Up to 1936, Congress had concentrated on the agricultural levees between Rock Island and Alton. In the 1936, 1938, and 1946 Flood Control Acts, it had authorized the Corps to reinforce the levee system below Alton. With the 1954 act, it came back to modernize the reach between Rock Island and Alton Under this act, Congress called for the modification or construction of 14 rural levee projects within the Rock Island District. Between Rock Island and Hamburg, Illinois, this act called for improving 335 miles of levee to protect agricultural land along both sides of {a} 200-mile stretch of the Mississippi River. Adding the Sny Island Levee and Drainage District to this, which had been approved by this act and lay in the St. Louis District, increased the total miles of the levee improvement to 386. The act also included the Upper Iowa River project near New Albin, Iowa, which entailed improving the outlet of the river at its confluence with the Mississippi River to protect agricultural lands. Through this act, as they had done under the others, farmers strengthened their hold on the upper Mississippi River's flood plains.

Urban projects received attention as well. The 1954 act included projects for four urban areas: Alton, Illinois; Hannibal, Missouri; and Sabula and Muscatine, Iowa. Although Muscatine and Hannibal lay on the Mississippi River, the projects at these cities were to protect them from flooding on the tributary rivers. As in 1950, the 1954 act authorized no work on agricultural levees on the upper Mississippi River's tributaries; nor did it approve any urban levees for cities on tributaries off the Mississippi River.

With the most important agricultural levees on the upper and middle Mississippi River being secured, Congress concentrated on urban levees and broad flood protection on the Mississippi River tributaries in the 1958 Flood Control Act. In it, Congress approved four projects for Minnesota: the Winona and St. Paul-South St. Paul projects on the Mississippi River, the Mankato-North Mankato project on the Minnesota River, and the Rushford project on the Root River. Rather than a levee, Congress authorized a large earthen dam to protect the small town of Spring Valley, Wisconsin, on the Eau Galle River. The largest project under the 1958 Act was the Saylorville dam and reservoir on the Des Moines River, about 11 miles above the city of Des Moines. Congress authorized this reservoir to supplement the flood storage capacity of the Red Rock reservoir to reduce the flood levels downstream on the Des Moines River, especially at Des Moines, and to lower Flood levels on the Mississippi River.

The 1958 act also called for two extensive projects for tributaries in Illinois. On the Rock and Green Rivers, which flow into the Mississippi River near Rock Island, Congress approved a long levee project protecting mostly agricultural lands and some small towns, roads, and railroads (this project was never built and is now listed as inactive). On the Kaskaskia River, which flows into the Mississippi River near Prairie du Rocher, Illinois, Congress approved the construction of levees to protect agricultural lands and the building of two dams: Carlyle (which had been authorized in 1938) and Shelbyville.

Building on the heritage of agricultural levee protection and responding to growing urban populations, Congress and the Corps expanded the flood protection program to include urban levees, reservoirs, and diversion projects between 1944 and 1958. But only once these projects and those authorized earlier had been built would the flood protection infrastructure of the upper and middle Mississippi River and its basin take shape. Projects completed by the Corps up to 1960 were largely done so under acts authorized before 1940. Prior to 1950, the Corps had completed 18 agricultural

protections for the main stem and no urban projects. By 1960, the number of completed agricultural projects had grow to 31, but only 3 urban projects had been completed on the upper river. Of these, only Sabula, Iowa, was on the upper Mississippi River proper. Aitkin, Minnesota, rests on the Mississippi River about 130 miles north of St. Paul, and Galena is a few miles off the main stem on the Galena River. Clearly, urban flood control on the main stem was in its infancy as of 1960.

HISTORICAL EVALUATION

Lower Mississippi River Valley

Verbatim from Mississippi Valley Division Potamology Study T-1, University of Missouri-Rolla, St. Louis District, U. S. Army Corps of Engineers, 30 June 1976

The natural condition of the Lower Mississippi River is that of a meandering sedimentary stream which deposits its alluvium over the floodplain during high water. The pattern of alluvium distribution has determined the development of the river and has had important consequences for later levee construction. The geological history of the river is well treated by Fisk in his various reports. In discussing allurvial deposits (1947), he states:

> Under natural conditions the river channel was unable to accommodate all of its high-stage flow and overtopped its banks periodically. Great quantities of silty and clayey sediments were laid down by these flood waters, forming natural levees along the banks of the stream. The natural levee is typically best developed on the outside of river bends as a low sloping wedge like ridge of sediments, over a mile in average width, tapering into the adjacent lowlands.
>
> These levees are being constructed above the general level of the floodplain basins and are the topographic forms which cause the meander belt to stand up as an alluvial ridge...Because of the fertility of the soil and the comparative ease with which it drains, the natural levee is the site of most of the agricultural land in the lower Mississippi Alluvial Valley.

Fisk also reports that these natural levees, while lower than 15 feet in the northern part of the Valley, are generally greater than 25 feet above the surrounding floodplain in the southern section. Humphreys and Abbot, in a study published almost a hundred years earlier, also noted the height of the natural levees near the river and included the following table of slopes in their report.

TABLE 7.1

Slope of the natural banks of the Mississippi.

Locality.	Bank.	Fall in first mile from river.	Authority.
		Feet.	
Near Cairo	Right.	4	Cairo and Fulton railroad company.
Near Memphis (measured from bank of Mill-seat lake)	Right.	6	Military road—Memphis to Little Rock.
Near Prentiss	Left.	7	Delta Survey (party of Mr. Pattison).
Near Gaines' landing	Right.	5	Gaines' landing and Fulton railroad company.
Northern boundary of Louisiana	Right.	8	Professor C. G. Forshey.
Near Lake Providence	Right.	8	Providence and Fulton railroad company.
Near Natchez; measured from bank of lake Concordia	Right.	8	Delta Survey (party of Mr. Pattison).
6.6 miles above Williamsport	Right.	7	Delta Survey (party of Mr. Ford).
1.3 miles above Williamsport	Right.	5	Delta Survey (party of Mr. Ford).
Below Williamsport, near Morgan's	Right.	9	Delta Survey (party of Mr. Ford).
New Texas road	Right.	10	Swamp-land commissioner's office, La.
11 miles above Point Coupée church	Right.	3	Delta Survey (party of Mr. Ford).
3 miles above Waterloo	Right.	12	Delta Survey (party of Mr. Ford).
4 miles below Port Hudson	Right.	9	Delta Survey (party of Mr. Ford).
7 miles below Lobdell's store	Right.	5	Delta Survey (party of Mr. Ford).
5 miles above Baton Rouge	Right.	3	Delta Survey (party of Mr. Ford).
Grosse Tête railroad	Right.	10	Dr. William Sidney Smith.
6 miles below Baton Rouge	Right.	13	Delta Survey (party of Mr. Ford).
7.5 miles below Baton Rouge	Right.	12	Delta Survey (party of Mr. Ford).
1.5 miles above bayou Manchac	Left.	6	Delta Survey (party of Mr. Ford).
Opposite bayou Manchac	Right.	11	Delta Survey (party of Mr. Ford).
4 miles above Bayou Goula	Right.	10	Delta Survey (party of Mr. Ford).
1.5 miles above Bayou Goula	Right.	6	Delta Survey (party of Mr. Ford).
8 miles below Bayou Goula	Right.	5	Delta Survey (party of Mr. Ford).
1 mile below Domenique's landing	Right.	6	Delta Survey (party of Mr. Ford).
8.5 miles above Donaldsonville	Right.	3	Delta Survey (party of Mr. Ford).
5 miles below Donaldsonville	Left.	5	Delta Survey (party of Mr. Ford).
10 miles below Donaldsonville	Left.	9	Delta Survey (party of Mr. Ford).
10 miles below Donaldsonville	Right.	6	Delta Survey (party of Mr. Ford).
20 miles below Donaldsonville	Left.	8	Delta Survey (party of Mr. Ford).
4 miles above Bonnet Carré church	Right.	7	Delta Survey (party of Mr. Ford).
Upper end Bonnet Carré crevasse	Left.	10	Delta Survey (party of Lieutenant Warren).
Lower end Bonnet Carré crevasse	Left.	3	Delta Survey (party of Lieutenant Warren).
Barataria canal	Right.	7	Surveys of canal company.
1 mile below Barataria canal	Right.	4	Delta Survey (party of Mr. Ford).
Near New Orleans	Right.	10	New Orleans and Opelousas railroad company.
Near New Orleans	Left.	10	Mr. G. W. R. Bailey.
11 miles below New Orleans	Left.	8	Delta Survey (party of Mr. G. C. Smith).

The general composition of these natural levees, as reported by Fisk is given in the following figure.

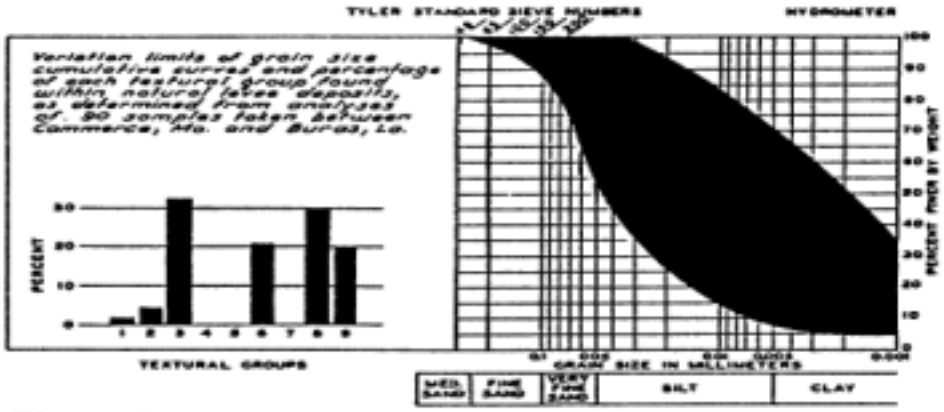

Figure 7.1 NATURAL LEVEE DEPOSITS

TEXTURAL GROUPS: COMPOSITION VARIES FROM SAND TO CLAY. CHARACTERISTIC TEXTURAL GROUPS ARE SANDY SILT, CLAY SILT, SILTY CLAY AND CLAY. THERE IS A GRADUAL DECREASE IN GRAIN SIZE SOUTHWARD FROM CAIRO, ILL. THE PERCENTAGE OF SANDY AND SILTY MATERIALS ALSO DECREASES AWAY FROM THE CREST OF THE NATURAL LEVEES.

SORTING: SANDY AND SILTY SEDIMENTS OF THE COARSER TEXTURAL GROUPS ARE USUALLY WELL SORTED, THE CLAYS ARE REPRESENTED BY THE COARSER HALF OF THEIR GROUP AND ARE GENERALLY POORLY SORTED.

WATER CONTENT: GENERALLY VERY LOW. LENSES OF CLAYEY SEDIMENTS OCCASIONALLY HAVE HIGH WATER CONTENT.

ORGANIC CONTENT: EXTREMELY LOW. SMALL LAYERS OCCUR LOCALLY.

COLOR: USUALLY LIGHT IN COLOR, VARYING FROM TAN, BROWNISH GRAY TO LIGHT GRAY. COLOR IS INFLUENCED BY SOURCE OF SEDIMENTS; RED AND ARKANSAS RIVERS CONTRIBUTE BROWN AND RED SEDIMENTS.

THICKNESS AND DISTRIBUTION: OCCURRENCE LIMITED TO NARROW ZONES ALONG PRESENT AND ABANDONED RIVER COURSES. THICKNESS OF THESE DEPOSITS VARIES WITH LATITUDE AND POSITION ALONG STREAM. DEPOSITS ATTAIN THEIR MAXIMUM THICKNESS AND DISTRIBUTION ON THE OUTSIDE OF BENDS. DEPOSITS ARE SELDOM OVER 15 FEET THICK IN THE NORTHERN PART OF THE VALLEY AND INCREASE TO A MAXIMUM OF ABOUT 25 FEET IN THE DELTAIC PLAIN REGION.

STRATIFICATION: GENERALLY MASSIVE, WELL-BEDDED EXTENSIVE LAYERS.

The natural levees from the highest aggradational floodplain feature and, as such, exhibit a significant influence on the river and the development of the floodplain. The surface drainage away from the river has turned the adjacent lowlands into back swamps into which the finest clays and silts carried by flood waters, are deposited. Also, since the natural levees are higher than the surrounding floodplain they tend to block drainage from the floodplain back into the main channel and force it into secondary tributaries

that ultimately enter the main channel at a lower elevation. Because of this, the back swamp areas are rather poorly drained. "When the natural levee deposits become too high, the river confined by them often breaks away during flood times and forms a new channel through the interstream depression." The natural levee is also subject to destruction by bank caving which may occur during low water. As the river's current impinges on the banks, strata underlying the natural levee may be eroded until the overburden load collapses into the stream and is carried away as sediment. Natural levees formed by river deposition have obviously been important agents in determining the course of the river and the morphology of the river's floodplain. The natural levees also had and still have an important influence on the settlement patterns and land use of the floodplain. It is obvious that the landforms established by deposition during flood stages are susceptible to inundation from later high water. If the natural levees are submerged, the lowlands behind them are covered even more deeply. In discussing this fact J.A. Ockerson (1903) states that while people saw flood depths of three or four feet over the natural levees, "They did not appreciate the fact that perhaps five miles farther back the water was 10 ft., or more, in depth." The first Mississippi flood on record occurred in 1543 (Elliott, 1932). It began in early March and was not back within the banks until the end of May, about eighty days after it had begun. Although water was again confined by the natural levees, the lower lands behind them must have taken longer to clear because of the poor drainage of the backswaps. With floods of such depth and duration, it is apparent that no permanent settlement or cultivation could be established along the river without making provisions for floods. The use of artificial levees for the protection of man, his properties, and his endeavors began with the very first settlement of white men on the Mississippi floodplain. When Bienville chose a site in 1717 for the City of New Orleans, his engineer, de Latour, objected on the basis that it would be easily inundated by high water. Upon being overruled, de Latour constructed an earthen embankment, modeled after the European levees, to protect the city. It was only four feet high, 5400 feet long, and 18 feet wide, but it proved to be sufficient for protection. As settlement progressed along the river, the levee line was extended by individual landowners at their own expense both above and below the city to prevent flooding of the farmlands. To allow the greatest area for cultivation, to utilize the best agricultural soil, and to keep construction expenses low, these levees were set close to the river along the top of the natural levees. This meant that the levees often failed due to caving banks. Apparently this did not discourage construction, for by 1735 the levee line extended about thirty miles above New Orleans on both sides of the river. No specifications for levee grade and section for this period are known, but some minimum criteria must have existed, since levee construction did become the official policy of the French government. Riparian landowners were required to complete their levees by January 1, 1744, or forfeit their lands to the Crown. The required levees were small by today's standards and crevassed often, but they provided enough protection to be put into general use. What effect the leveling of this portion of the river had on the Mississippi itself cannot be assessed. The river was still free to flood above this section and outlets such as the Atchafalaya were still unobstructed. Furthermore, according to Fisk, the alluvial deposits below Baton Rouge are mainly clays, as opposed to sandier alluvia above this point. Clay deposits resist erosion much better than sand, so any change in the channel due to levees would be slow and, in the absence of precise observations at the time, impossible to determine. The use of levees by individuals for flood protection continued even after the transfer of Louisiana to the United States and by 1812, the east bank had levees up to Baton Rouge and the west bank forty miles beyond that. By 1844, the west bank levee line was almost continuous up to the Arkansas River, while only a few levees protected the Yazoo Basin on the east side. During most of this period, it appears that there was very little planning done as to the location, dimensions, etc, of the levee system. Some of the largest levees were indeed built with engineering considerations, but this was generally not the case. The levees from the French period and after were constructed by the riparian landowners and supervised by local authorities to ensure adequate strength. What constituted adequate strength seems to have been based on experience rather than on any engineering criterias. As settlement continued, the task of flood control increased and slowly the engineering of levee construction became

more important. For example, in 1833 Louisiana created a post for a civil engineer to be a supervisor of public works, including levees, and in 1835 legislatively specified the dimensions of the Concordia Levee. Larger engineering questions of flood control were also discussed. According to Harrison,

> The long debate on the best plan for protection of the Alluvial Valley began in the 1840's. The need for outlets for Mississippi River flood waters was discussed with attention to their possible location. Reservoirs were mentioned occasionally as a possible protection, but immediate efforts were directed toward levees as the only practical means of flood control.

Such attention to levees was given that by 1858 William Hewson was able to publish a detailed study of the various engineering aspects of levee construction and could recommend specifications for dimensions, materials, etc. With the gradual accumulation of knowledge about levees by landowners, engineers, and the States, over six hundred miles were erected before the Federal government became involved, to any major degree, in levee construction in 1850. Previous Federal involvement consisted simply of granting land for particular levees when these levees were being built. Under the prompting of Louisiana and several other states, Congress eventually passed a series of bills, the Swamp Acts, in 1849 and 1850. These granted all swamps and overflowed lands to the States, provided that the States would construct levees to protect the areas and open the swamps to cultivation by draining them. These laws are loosely worded and the actual intent of the Congress is unclear. Elliott feels that they were intended to be flood control legislation, while other writers, citing grants to States outside the frequently inundated Mississippi Valley such as Oregon, Michigan, and Florida, stress that the reclamation of wetlands was the basic intent. In much of the literature on the Lower Mississippi Valley "reclamation" and "flood control" appear to be almost synonymous. Thus, it cannot be claimed that the Swamp Acts are a clear statement of a Federal desire for flood control by an extensive levee system. It must also be stressed that the Federal government merely granted the lands for reclamation but expended no funds to aid this project. For example, even the surveys to determine what swamplands actually existed were done at the States' expense. The major effect of the Swamp Acts in the Mississippi Valley was to organize levee construction much more than it had been. Responsibility for the levees had been slowly passing from the landowners to the States, but now the States assumed an even greater role as they began to specify grades and sections, and set up administrative systems for construction and maintenance. The expense of the levees were now assumed, through bonds and taxes on reclaimed land, by people other than the riverside landowners. Unfortunately, the levees built under this system were not large enough, poorly located and poorly constructed, while the administrative systems were defectively organized, and coordination between states was difficult. In spite of these failings, much practical experience with levee construction was gained by engineers and the levee system built was the best yet achieved. One contemporary evaluation of the system, while admitting its deficiencies, states:

> Great practical good, however, has resulted even from the perfect application of the system; for without it the greater part of the alluvial region below the mouth of the Ohio would be an uninhabitable swamp in the high water months of the year.

In 1850, Congress also authorized a detailed survey of the river with a view to determining "the most practical plan for securing it from inundation." Capitan A. A. Humphreys and Lieutenant H.L. Abbot made detailed observation of the river in 1851 and 1858 and considered a variety of proposed methods for flood control. The importance of the Delta Survey's report cannot be underestimated, for its conclusion that levees alone could control the river was accepted by later studies and eventually became the basis of flood control on the river, despite many other proposals. Until this point, levees had been built as necessities and little consideration was made of their potential effect on the river. Humphreys and Abbot, on the other hand, were required to make such an evaluation and much of their work included obtaining the precise data needed for such a task. Some interested people had kept stage records for a few cities, but a general collection of data did not exist. Thus, a major effort of the Delta survey was the establishment of gages at various points along the river, and making a detailed study of

the topography and characteristics of the Mississippi and its tributaries' basins. Utilizing these data, Humphreys and Abbot considered a series of flood control measures. The proposals generally followed one of two philosophies, later characterized by Corthell (1882) as a "Dispersion Theory" and a "Concentration Theory". The first is based on the principle that if one could get the water to the Gulf more quickly, either by shortening the river or by providing more outlets, floods would be lowered. The second functions on the basis that confining the water to the main channel would force the river to conduct all of its floodwater to the Gulf without spreading over the floodplain. Artificial cutoffs, designed to shorten the river, were decided to be impractical if they must be constructed from the mouth to the point where flood reduction is needed, as proponents desired. A cutoff of a single bend, while it would certainly depress flood stages above it, would merely raise stages below because the river could not handle the increased amount of water. Cutoffs, whether natural or artificial, were thus to be prevented. Artificial outlets, designed to remove the extra amount of water needed to create a flood, were considered in great detail These were to be constructed either by creating new outlets or by enlarging already existing bayous which run parallel to the Mississippi. It was concluded that crevasses, and therefore outlets, do not induce sediment deposition immediately below their openings, a conclusion still contested years later, but the disposal of water after intake was the proposal's main defect. Some bayous were too long to be enlarged practically, while other might enlarge too much and divert too much of the river. In the case of a Bonnet Carre or Lake Borgne outlet, sediment deposition at the mouth would cause many problems. In general, outlets were seen as impractical, but it must be remembered that Humphreys and Abbott were considering all-season outlets, not spillways. Diversion of tributaries such as the Missouri, Arkansas, and Red Rivers, to reduce the total amount of water to be conducted by the Mississippi, was rejected. Humphreys and Abbott did not have all the data they felt they needed to make an absolute conclusion, but from what they had it appeared either that the diversions would create more injury once they were made or that they would have little effect on the Lower River. The final alternative to levees considered was the use of reservoirs. Humphreys and Abbot admitted that retention of water during floods and subsequent release during low water would have a negligeable effect on the Lower River, because much of the rainfall causing floods falls directly over the Valley. On the other hand, reservoirs in the Lower Valley would be impossible because there are not suitable locations for them on the floodplain. After the discussion of the alternatives, the Delta Survey report contains a long analysis of levees and their effects. The main objection to levees with which Humphreys and Abbot dealt was that levees cause an elevation of river beds. Based on the European experience with the Po, it was argued that the sediment ordinarily spread over the floodplain would now be dumped on the river bed, raising the river surface, and thereby requiring a further heightening of the levees. This idea was dismissed based on further observations of the Po by Chevalier Lombardini. Following discussion of their observations, Humphreys and Abbot concluded that a fully-leveed river with no crevasses would have floods up to ten feet higher than that of 1858. Because of the increased head and the resultant velocity increase, these floods would be of shorter duration. It was therefore recommended that a levee system be built below Cape Girardeau, Missouri, of sufficient height to contain the increased flood stages. A single outlet near Lake Providence connected to Bayou Tensas was also suggested as a possible way to reduce the stages in this reach of the river. Much of the Delta Survey's conclusions rest on the assumption that the bed of the Mississippi consists of hard, virtually non-erodible blue clay. Thus Humphreys and Abbot did not claim, as later proponents did, that levees would deepen the channel, for they felt any increase must be made at the expense of the banks, producing a wider but not deeper channel. They must have felt this deterioration of the natural levees by the artificial levees was already taking place. In considering the use of bank heights in leveed sections as indicative of previous flood heights, they state that:

> "...crevasses may reduce the surface of the river as low as, if not lower than, it would have been if the natural banks existed in their original, unleveed condition, for the mean level of the natural bank, where the levee system has been in operation for many years must, from

constant caving, be lower than it was originally.✍

Before any action was taken on further flood control, the Civil War intervened and with the States' energies focused elsewhere, the existing levees were crevassed and many washed away. After the war the States were too impoverished to maintain the levees to any great extent, and the main Federal effort on the river was aimed at navigation improvement, not flood control. Although little construction was taking place, engineers continued to discuss the issue of levees and their effects. Some rejected the Delta Survey's conclusion about the permanence of the river bed, claiming considerable deepening would or had occurred and thus there would be no increase in flood heights. Hewson, in his Principles and Practices of Leveling, was not concerned with the bed, but suggested that a slow increase in flood heights would begin as the delta was extended by the increased amount of sediment carried into it. Others stood by the conclusion that the bed would remain at the same level, while still others continued to believe in the elevation of the bed. Obviously, the Delta Survey had not settled the question of flood control, but it did provide necessary data for subsequent discussion. While levee construction and flood control continued under the old system, the federal government became more involved in the navigational aspects of the river. Since 1824, the Corps of engineers had been charged with the removal of snags from the stream and other channel improvements. The first dredging occurred in 1856 and was attempted again in 1867; river gages were constructed in 1875. With this emphasis on navigation improvement, little investigation was made into flood control, but the studies which were made reached important conclusions. A commission studying the impact of the 1874 flood on the levees clearly defined the grave deficiencies in the system for levee construction and administration. Elliott reports as follows:

✌In its report, submitted in 1875 and based largely on the work of Humphreys and Abbot, the commission found the existing system defective as the result of five principal causes, to-wit: vicious levee organization' insufficient levee height; injudicious cross section and construction; inadequate inspection and guarding; and faulty location. The Commission expressed its opinion that no practicable aid could derive from any diversion of tributaries or by artificial reservoirs; that cut-offs were pernicious in their effects; and that outlets, although correct in theory, would find no useful application on this river. A general system of levees from the head of the Alluvial Valley to the Gulf, including the valleys of the tributaries, was advocated, and it was recommended that this project be executed under the general supervision and control of a board of commissioners

which would report to the supreme authority from which it would derive its legal existence. The board further stated that little could be accomplished under the existing conditions without Federal aid.✍

Another report in 1879 by a board of engineers considering low water navigation combined the theories of levees and navigation improvement in a manner foreshadowing the future Federal Stance on levees. Elliott again reports:

✌(The Board) advanced the conclusion that a complete levee system would aid commerce during periods of high water but would have little or no influence upon low-water navigation. The Board stated that the greatest obstacle to navigation improvement and levee maintenance was the instability of the river due to bank caving. The Board concluded that the levee system, if undertaken, should be developed in connection with navigation improvement.✍

With the establishment of the Mississippi River Commission in 1879, the entire Federal program on the river entered a new phase. The commission consisted of four government and three civilian engineers appointed by the president and reporting directly to the Secretary of War. The jurisdiction of the MRC was confined strictly to the Mississippi from Cairo to Head of Passes, but within this area there were now two engineering bodies, the MRC and the Corps of Engineers. To insure cooperation, the president of the MRC and two commissioners were to be from the Corps. The MRC was charged with improving the river channel to aid navigation, protecting the banks, preventing destructive floods,

and aiding commerce and the mails. Harrison correctly notes the debate in Congress over the true reasons for this legislation. Was it for navigation or for flood control? Opponents to the new arrangement argued that while navigation was definitely a national concern, flood control should be handled strictly by local concerns. They feared that this step would eventually result in large expenditures by the Federal government for flood control. Proponents solved the dilemma by considering both concerns as part of the same problem. They stressed that navigation improvement was their primary aim, but if some relief from floods resulted from this work, so much the better. Illuminating, perhaps, are the opinions of one supporter, Rep. Gibson, which demonstrate this emphasis:

> "In the first place, official reports show that during several months in every year immense sandbars and snags close the navigation of the river as effectually as if artificial dams were constructed across its channel. In the second place, official reports show that at other seasons the river rises over its banks throughout the alluvial region and spreads over the country for forty to sixty miles--becomes mighty roaring torrent--destructive not only to human life and property upon its borders, but destructive to the commerce upon its waters...In such seasons the largest boats propelled by steam are sometimes destroyed and often detained several days by the extraordinary obstacles they encounter, but that countless fleets of smaller boats, barges, and and flatboats, propelled by the current of the river itself, are absolutely at its mercy and are sometimes borne into the adjacent forests and wrecked or whelmed and destroyed in the furious eddies and cross-currents...This commission is created with the hope that they may devise some plan, economical, feasible, and complete, that shall give us deep water at all seasons of the year and prevent these destructive floods so ruinous not only to the country through which it flows, but to the mighty commerce that carried the production of the teeming millions who inhabit the great valley to the market of the world and brings back in exchange the wealth of other countries."

The plan submitted by the MRC in 1880 followed closely the suggestions of the Delta Survey and the 1879 Board. Although levees were not absolutely necessary adjuncts to navigation improvement, they were desirable for they were thought to deepen and enlarge the channel. Bank revetment, permeable contraction works, and the closure of chutes and alternate channels were also among the recommendations accepted and funded by Congress. In order to administer the construction of levees, the MRC simply adopted the existing system of levee districts which has been set up earlier under the States' jurisdiction. At the time, the levee districts had ample funds, while the MRC was dependent on congressional appropriations, so the new levees were mainly built with district funds. The MRC acted as a coordinator between the districts and States. The Commissioners were not all agreed as to the true value of levees in relation to navigation, but since they were under Congressional instructions to build levees only as aids to navigation, they had to justify any construction in these terms. It was decided in 1882 that levees would be built to grade sufficient to hold the most frequent floods, but the cost of restraining abnormally high floods could not be justified. To accomplish this, gaps and crevasses were to be closed and the levee line was to be extended upstream. The history of the MRC until 1917 was a repetition cycle of new high-water stages followed by new levee grades. These grades were set in reference to local high water with correction for water lost through crevasses and new upstream levee construction, rather than designing them for a projected flood, the present practice. This meant a new levee at one place occasioned higher levees elsewhere, and the levees were raised in see-saw fashion. For example, during every flood the low levees guarding the St. Francis basin crevassed, providing relief to the much higher levees on the east bank. The controversial closure of the front raised the 1897 flood heights at Memphis by 2.5 feet, causing great strain on the eastern levees.

The Commission recognized that levees would increase flood heights, but with each new flood the crevasses always occurred at points where the levees were still below Commission grades. The belief in the ultimate deepening of the channel and in the impracticality or injurious effects on navigation of

other flood control measures encouraged the Commission to stand by its "levees only" policy, despite the continuing opposition by some engineers to it. The debate over the effectiveness of levees was quite extensive, and many other types of flood control were discussed. The Transactions of the American Society of Civil Engineers contain many debates and discussions of levees and alternatives to them. Some writers, such as Robert McMath (1994), attempted to demonstrate that the very theory behind levees was inherently faulty and the levees thus destined to failure. Others merely argued the feasibility of supplementing levees with other devices, such as outlets and reservoirs. One writer even advocates constructing a secondary stem on the western edge of the alluvium to decrease the total volume of water to be carried by the Mississippi. This may be a rather unusual suggestion , but it indicates the range of alternatives being actively considered. Any reader interested in the general feeling of these debates would be well-advised to read "The Levee Theory on the Mississippi: An Informal Discussion", Transactions of the ASCE (1903). These alternatives to levees were not accepted by the MRC and levee proponents at that time, but many points raised in the debate were ultimately utilized for flood control. For example, as early as 1882 emergency outlets to decrease dangerous flood heights were suggested. The Bonnet Carre spillway presently operates on this principle. As the years progressed the focus of the MRC expanded from primarily navigation improvement to include flood control as a major part of its work. It was eventually conceded that the levees' influences on the navigation channel were only slight, but the passage of the first flood control act in 1917 finally permitted the MRC to build levees just for flood control. The act also made changes in the financing of the levees by stating that Federal funds would pay two-thirds while local interest would pay one-third of construction costs, as well as provide the right-of-ways and assume maintenance after completion. Levees constructed entirely by local interests were not prohibited. Although retarded a bit by World War I, the levee building progressed until almost the entire line met MRC standards and the remaining gaps were closed. The successful high-water fight of 1922 brought increased optimism to the Valley about flood control. This optimism was not totally shared by the people intimately involved in flood control. Those constructing levees recognized the great danger still posed by caving banks and pressed for more bank protection. They also realized that floods greater than 1922 could occur and that another raising of levee elevation was required. Others, such as the City Engineer of New Orleans, felt that levees alone were inadequate and should be supplemented with spillways. Throughout this period, the MRC continued its "levees only" policy, but other flood control agencies were considering alternatives. In 1924 the Chief of Engineers, Gen. Lansing Beach, stated:

> "It is to be expected that in the future, as in the past, various alternative plans will be urged for achieving the results desired....All these proposals have been investigated and reported on time and again. However, with the growth of the art of engineering, plans which were not practicable in the past may become feasible in the future, and the Engineer Corps will maintain an open mind in the investigation of any reasonable means for river control that are presented by responsible organizations or able engineers."

The MRC claimed no less a willingness to listen. In the words of its president:

> "The Commission is often criticized because it does not hasten to adopt suggestions made to it. People think it so committed to archaic ideas that it will not accept suggestions from the outside--is unwilling to admit that anyone from the outside can tell it anything. On the contrary, it is glad to hear any suggestion. But when a man comes in with the same old thing that has been considered, possibly tried and discarded-nothing new about it except a name-the Commission cannot go all the ground again. The public is loath to give credit for the amount of thought the Commission has put on river problems--thinks it obstinate when it adheres to principles that have been proven by forty- five years of careful study and observation."

The MRC showed its continuing faith in these proven principles when it considered a proposal for a spillway below New Orleans leading to Lake Borgne. With the aid of Gen. Beach, a group of New Orleans businessmen and professionals had submitted a detailed plan, but after considering it, the MRC

replied that, with only the slight reduction in stage, the lengthening of levee lines, and the negative effects on the river by the spillway, ✐it would be wise first to make the city safe by tried methods which are wholly feasible and much cheaper. The confidence of the MRC in ✐levees only✍ and the security felt by the valley inhabitants were shattered by the extraordinary flood of 1927. For the first time, completed levees built to the existing MRC grades were overtopped and crevassed. It was called the greatest disaster of peace times in our history,✍ by Secretary of Commerce, Herbert Hoover. It killed at least 246 people and left 700,000 homeless while creating over $400,000,000 in losses and damages. The magnitude of the flood and the resulting national attention forced a total review of the existing system of flood control. Congressmen were beseeched to act with passionate appeals, such as that of Rep. Gregory of Kentucky:

> ✐Mr. Chairman and gentlemen of the committee, those of you who just a year ago witnessed the mad rush of the mighty Father of Waters, sweeping like a destroying angel over hundreds of proud cities, thousands of happy and contented homes, and millions of fertile fields, or who later visited the stricken area to view the scenes of the greatest peace-time disaster this country has ever experienced, know how futile would be the effort of the most gifted tongue or the most facile pen to describe the wreckage and the ruin, the horror and the agony which were left in the wake of the 1927 flood.✍

Long Congressional hearings were held and detailed plans for flood control were submitted by both the MRC and the Chief of Engineers, General Jadwin. What is striking about the new proposals is the universal agreement that levees alone were incapable of providing the necessary protection. The MRC was strongly criticized by the House Committee on Flood Control for its strict adherence to the ✐levees only✍ policy, and in its own new plan, levees were to be supplemented by floodways, including a spillway to Lake Borgne. A similar system was proposed by Jadwin, but while both plans urged the raising and strengthening of the levees, they included different floodways. Jadwin recommended building a levee about five miles back from the river running from Birds✒ Point, Missouri, opposite Cairo, Illinois, to New Madrid, Missouri. The area between the levees would be flooded during great floods, dropping flood stages at Cairo. Similar floodways were proposed to conduct extra water down the Boeuf Basin and The Atchafalya. These floodways would be activated by an untried device, a fuse-plug levee, which raised great controversy. The principle involved the construction of a section of the riverside levee, deliberately smaller in grade and section. This section would crevasse naturally at a certain stage, allowing water into or out of the floodway. The final feature of the Jadwin plan was a spillway at Bonnet Carre to let flood waters into Lake Pontchartain. The MRC plan extended the levees up to Rock Island, Illinois and also provided for the Beouf and Atchafalaya floodways, but none in Missouri. Instead of fuse-plug levees, entrance to these areas would be controlled by concrete spillways. Two spillways would also be built to protect New Orleans, one above at Bonnet Carre and one below at Caernarvon. The most hotly debated issued in Congress was not which engineering plan to accept, but whether local concerns should help pay for the chosen program. The economic devastation of the area raised the question of how much the people in the Valley, who already helped raise the former levees, could now pay. Some, like the President, felt that it would be wrong for the Government to pay the full expense of improvements which would make the protected lands more valuable. Others, like Congressman Reid, head of the House Committee on Flood Control, viewed the situation as follows:

> ✐Under the present law the United States says to the threatened ones, ☮No pay, no protection✒....
>
> Is our civilization so little removed from barbarism that it will permit hundreds to be drowned and thousands to be made homeless and destitute while, like shylock, it demands its pound of flesh from those who cannot pay?✒

Finally in 1928 Congress responded to the disaster of 1927 by making the control of the Mississippi a national project. The MRC was reorganized to be a consulting and advisory board under the Chief of Engineers and the Corps of Engineers took over the actual construction work. A board was

appointed to examine the two proposed plans and to recommend a comprehensive project; the Jadwin plan ultimately was accepted.

Present day policies are contained in various documents one of which is Engineer Publication 1165-2-1. There are many. Mostly they evolve around Federal, state and local responsibility and the consideration of proposed water resource projects alternatives. In the Interagency Floodplain Management Review Committee Report, of which Brigadier General Gerald E. Galloway was the Executive Director, extensive considerations were given to many alternatives to reducing flood damage following the Great Mississippi River Flood of 1993. One main feature of the report was recommendation for greater Federal involvement in a basic and systematic approach to flood plain management in the Upper Mississippi River. Valley. Objections to the recommendations centered on the increased Federal role recommended and the budgetary impacts. Budgetary impacts as the Federal Government attempts to reduce the deficit and/or create a surplus have caused for Fiscal Year 1999 a reduction in spending on many water resource projects and even more pressure to reduce operations and maintenance spending by the Corps of Engineers as well as other Federal Agencies.

This political climate drives the investments. Always has. In the 1930's during the Great Depression in which, under the Relief Act of 1935, work was recommended for reconstruction of levees to meet:

"18. Compliance with Fundamental principles recognized by the President:

This project complies with practically all the fundamental principles recognized by the President as vital to the Emergency Relief Program.

a. It is a useful project intended to protect life and property.

b. Its nature is such that approximately 60% of the total cost on the project will go into wages for labor....

c. It is estimated that with the exception of one or two projects 90% of the total labor can be secured from the relief roles of the various areas and can be put to work by August 1, 1935..."

Even though jobs were the main consideration, engineering and economics analyses were undertaken to invest in the best and not cause severe adverse impacts to flood heights.

Eventually the Corps as well as other agencies started to perform basic wide studies and with the exception of diversion of efforts during the war years continued to do so for many years. In E.E. Middleton's thesis for doctoral program for a degree of Doctor of Philosophy from Indiana University, 1984, he analyses the progress of comprehensive basic planning by water resource agencies from the 1930's through the 1970's and early 1980's. His analysis was that the Corps of Engineers, as well as other water resource agencies, basic planning changed with time to become more comprehensive and that the Corps civilian/military management system allows the Chief of Engineers to achieve change through the chain of command.

And change has happened. While Dr. Middleton was addressing organization change and documenting the changes, this author believes that despite historical data; despite the clear need for basin wide planning on the Upper Mississippi River Basin change has decreased basin wide planning throughout the United States and a "Master Plan" for the Upper Mississippi River Basin as exists under the Jadwin Plan adopted by congress and being implemented by the Mississippi River Commission will not happen until budgetary considerations (balanced budget/zero deficit/surplus) has been achieved. Even though system flood frequencies and profiles are being developed, there is not at this time (in the author's opinion) a drive to analyze the Upper Mississippi River Basin. The episodic method of allocation of curtailed water resource funds will continue to be followed.